

RXTE observations of Cygnus X-3

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Abstract. Cygnus X-3 is an unusual object. From the time of its discovery over 30 years ago, despite more and more sophisticated studies, its behavior still brings more questions than answers. We have collected all the public Cyg X-3 RXTE data and divided it into four groups in respect of the shape of the PCA/HEXTE spectrum. The two out of four groups are distinctly different from the widely known spectral states: hard and soft. Furthermore, using XSTAR and on the basis of the BeppoSAX data, attempts have been made to solve the problem of the strong and complex neutral and ionized absorption, referring to the system itself, its close vicinity and the interstellar medium across Galactic plane.

DATA

Data have been obtained with the PCA and HEXTE instruments on board the RXTE satellite. Data were collected in the years from 1996 up to 2000. PCU proportional counters used are PCA0, PCA1 and PCA2, and all photons that have been caught by the detector's first layer have been taken into consideration.

Hard state BeppoSAX observation was performed in September 1996.

SPECTRA

It is possible to divide public RXTE data into 5 groups
Fig. 1, 2:

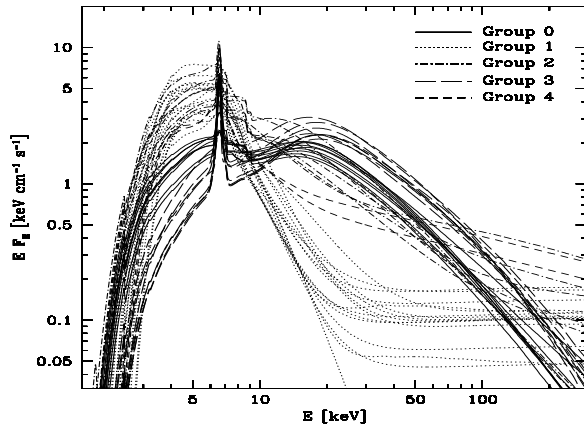


FIGURE 1. Eqpair model fitted to the public 1996-2000 RXTE data. Different line types represent different groups of spectra. Division has been made on the basis of the shape of the spectra.

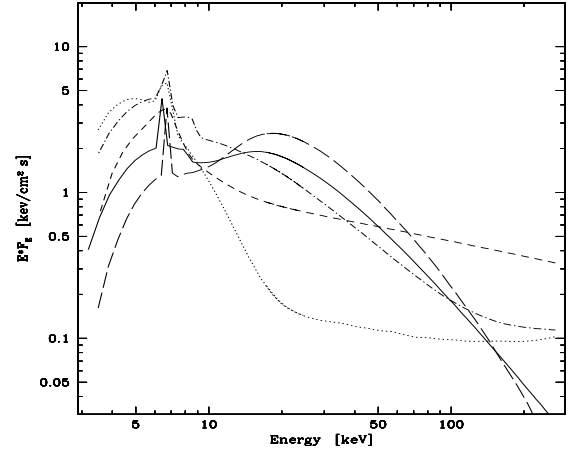


FIGURE 2. Models fitted to the sum of all spectra in each out of 5 groups shown on Fig. 1

- Group 1 represents soft state
- Group 0 and 3 represent hard state
- Group 2 and 4 represent probably transition between soft and hard state

Vertical variability between spectra in each group is caused by orbital modulation.

POWER SPECTRA

PCA power spectrum of each of the groups doesn't show any significant features in the range 0.003-100 Hz.

Lack of any significant millisecond variability may be caused by suppressing due to scattering in the wind of the Wolf Rayet companion star (McCollugh et al. 1998).

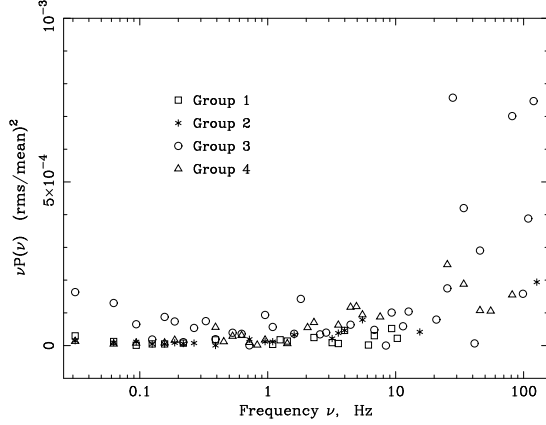


FIGURE 3. Power spectrum for four groups shown on Fig. 2. All available group 0 observations sets didn't contain sufficient data information to create the power spectrum.

LIGHT CURVES

On the basis of the dwell by dwell ASM/RXTE 0.5-12 keV light curve (Fig. 4), two distinct spectral states have been defined. Hard state: counts 0-20, soft state: counts 20-50.

Separated hard and soft state ASM light curve have been folded with the orbital period using the parabolic ephemeris by Singh et al. 2002. Time bin equals 0.01 s. A comparison doesn't show either any significant difference in shape of the curve or any phase shift (Fig. 5).

If during the state transition, system geometry change occur, it doesn't influence the variability connected with the orbital period.

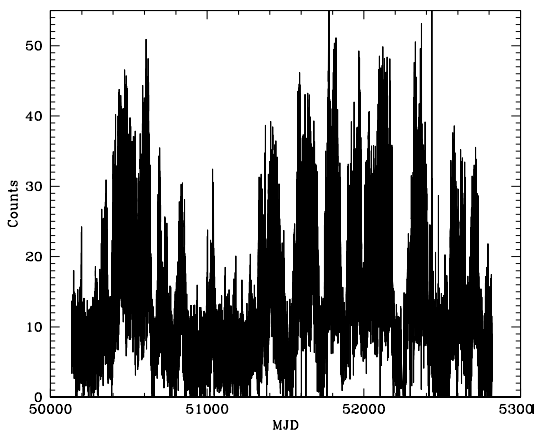


FIGURE 4. ASM light curve, dwell by dwell, 1.5-12 keV, 50087-52760 MJD.

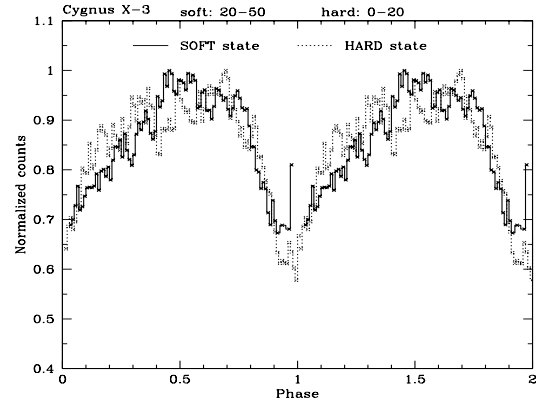


FIGURE 5. ASM light curve (Fig. 4) folded with the orbital period. Parabolic ephemeris given by: Singh et al. 2002. Hard state: counts (0-20), soft state (20-50).

PHASE RESOLVED SPECTRA

The three subsequent August 1996 RXTE observations in the hard state (Fig. 6, 7) have been divided into 18 unequal parts. In each part, duration doesn't exceed 15% of the full phase (4.8 h). 18 spectra have been created.

Each of these short time spectra have been roughly fitted with the comptonization model eqpair (Coppi 1999)

An analysis of spectral variation over the orbital period in the hard state indicates flux variability, minor changes in absorption amplitude and a change in an iron ionization state (Fig. 8).

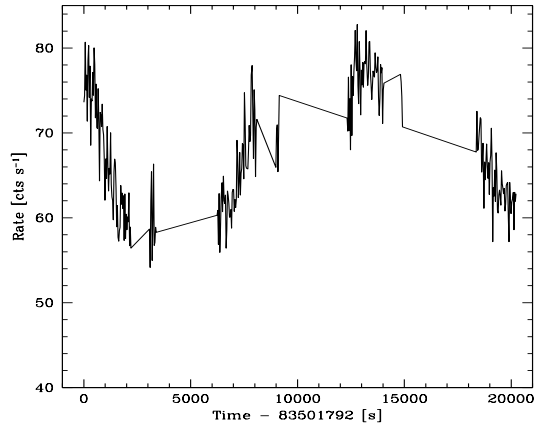


FIGURE 6. Screened PCA light curve, 24.08.1996, group 0, hard state.

In minimum (phase 0 and 1) there is a low ionization or neutral Fe absorption edge present (7 keV). In maximum (phase 0.5) high ionization Fe absorption edge is clearly

visible (9 keV). It probably originates from helium like iron.

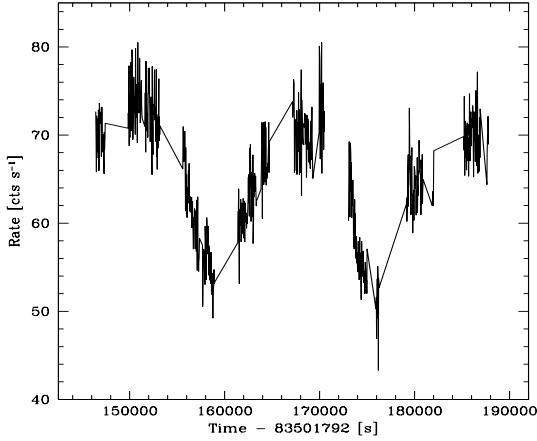


FIGURE 7. Subsequent screened PCA light curves, both 26.08.1996, group 0, hard state.

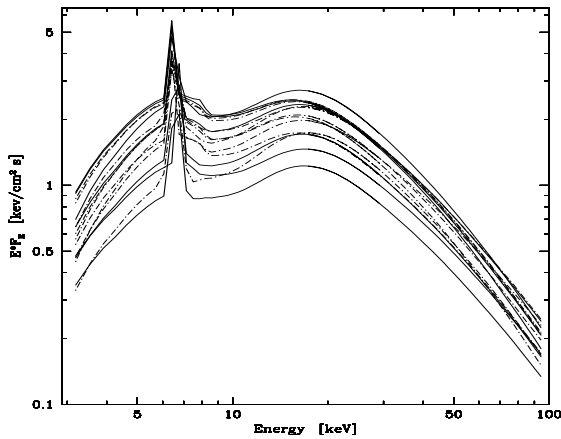


FIGURE 8. Eqpair model fitted to 18 spectra coming from different phase intervals seen on Fig. 6, 7. Phase 0 and 1 - minimum, phase 0,5 maximum. Phase 0-0.5 solid line, phase 0.5-1 dash-dot line.

FITTING

Absorption complexity that may vary during the orbital period is clearly visible on Fig. 9 - BeppoSAX data. Data fitted with comppps model, accretion disk line (Fabian et al. 1998), neutral absorption and ionized absorption model generated by XSTAR.

Further detailed analysis of possibly small data packages representing different phase intervals in different states requires data with much better energy resolution in the low energy band 1-10 keV.

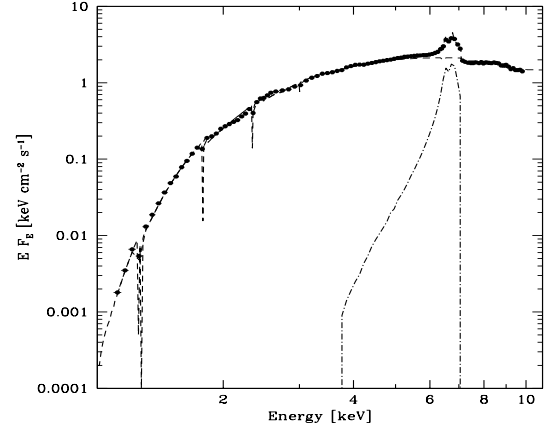


FIGURE 9. MECS/BeppoSAX data (dots) fitted with the complex model of comptonization COMPBS, accretion disk line and neutral and ionized absorption.

ACKNOWLEDGMENTS

This research has been supported by the Foundation for Polish Science and KBN grant 5P03D0021

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